## Reproductive strategies of a simultaneous hermaphrodite

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# Summary

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All the extant organisms are the consequence of reproduction by ancestors. This fact naturally invokes the urge to know how organisms managed to reproduce. Therefore, I studied reproductive strategy, which is defined as a set of (behavioural, morphological and physiological) traits that optimize reproductive success of an individual under given local conditions. As suggested by this definition, the evolutionary process of reproductive strategies is driven by sexual selection. In addition, I focused on simultaneous hermaphrodites, mainly the great pond snail *Lymnaea stagnalis* (L.). In contrast to separate sexed species, which are extensively studied, simultaneous hermaphrodites offer plenty of opportunities to expand the general understanding of sexual selection in unique ways. For instance, hermaphrodites do not have sexual dimorphism by definition, so one can test whether sexual dimorphism is necessary for sexual selection (Pélissié et al. 2012; Schärer et al. 2012). Therefore, in order to contribute to the general understanding of sexual selection from the hermaphroditic point of view, this thesis sheds light on multiple aspects on reproductive strategies of a simultaneous hermaphrodite, *L. stagnalis*.

First, I conducted a literature survey about reproductive strategies in hermaphroditic gastropods to propose conceptual and empirical approaches. I argued that (1) it is favorable to investigate traits with functions that contribute either to male or female reproductive success, i.e., sex-biased traits, (2) post-copulatory processes could play important roles in hermaphroditic gastropods and (3) it is necessary to examine the consequence of biased sex allocation for reproductive success. This review introduces research questions and background knowledge relevant for the rest of this thesis.

Given the expected importance of post-copulatory processes based on the previous chapter, I experimentally investigated how long *L. stagnalis* can store and use sperm from mating partners. I found variation in paternity longevity and male reproductive success even under well-controlled conditions. This finding indicates sperm storage ability is an important trait to evaluate reproductive success in simultaneous hermaphrodites.

Next, I investigated the unique function of seminal fluid proteins in simultaneous hermaphrodites, focusing on whether they could manipulate the male function of mating partners (Charnov 1979). This series of experiments revealed that receipt of specific seminal fluid proteins reduces sperm transfer and paternity success in *L. stagnalis*. Although it remains to be tested whether

this represents an adaptive response to mating by the recipient or manipulation by the donor, this finding uncovers an unexplored arena for reproductive strategies of simultaneous hermaphrodites, i.e., male function of their mates.

Then, I examined how the sex role, mating as male or female, is determined when two individuals meet. Such decisions are again unique in simultaneous hermaphrodites, since it has been pre-determined in separate sexes. I found that young and small snails tend to mate as males first, although old and large snails seem not to be better “females”. This finding and previous studies collectively suggest that their sex role decision is the result of sexual conflict, and not a harmonious agreement.

Lastly, I investigated natural populations of *L. stagnalis* to estimate the degree of multiple mating and sperm competition, since most studies of sexual selection in hermaphrodites were based on experiments in laboratory. My field and molecular data revealed an intermediate degree of multiple mating in wild populations. Moreover, the results hint at the importance of mate availability in this hermaphrodite.

In sum, I started with the literature survey, and carried out laboratory experiments to investigate pre- and post- copulatory processes of *L. stagnalis*. Furthermore, I observed the reproductive state of natural populations in this hermaphrodite. Therefore, this thesis illustrates the uniqueness and high potential of studying reproductive strategies in a simultaneous hermaphrodite, *L. stagnalis*, and has clearly contributed to our understanding of sexual selection in general.